Nocturnal ion events: 11 years of night-time ion activity in Hyytiälä, Finland

S. Buenrostro Mazon, H.E. Manninen, J. Kontkanen, T. Nieminen, V.-M. Kerminen and M. Kulmala

Department of Physics, University of Helsinki, Helsinki, 00014, Finland
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Presenting author email: stephany.mazon@helsinki.fi

New particle formation (NPF) contributes significantly to the total atmospheric particle loading, which in turn has significant health and climatic implications. The common practice when identifying NPF events is to analyze a 1-day size distribution (Kulmala et al. 2012), with a focus normally given to the morning hours and early afternoon when photochemical oxidation takes place. However, there are indications worldwide of night-time particle formation, such as the study by Wiedensohler et al. (1997) where an ultrafine mode of 5 to 15 nm was observed during midnight–early morning hours downhill to an orographic cloud. Suni et al. (2008) reported 'nocturnal aerosol formation' in the Eucalyptus forest of Tumbarumba, Australia, with 32% of their analysed nights presenting cluster (0.8–1.8 nm), intermediate (1.8–7.5 nm) and large (15–40 nm) ions activity. Kalivits et al. (2012) found 'nighttime enhanced ion concentrations' at Finokalia, Crete. Boreal forest nocturnal cluster events for SMEAR II Station, Hyytiälä, Finland, were introduced by Junninen et al. (2008) in a 4 year study (2003–2006), and continued by Lehtipalo et al. (2011) with a deeper analysis including neutral (nanometer condensation nuclei, or nano-CN) versus ion cluster comparison, and laboratory flow-tube experiments replicating the condensation of precursor monoterpene vapors as potential sources for the nocturnal nano-CN. This study investigates nocturnal ion activity from an 11 year time series (2003–2013) of negative and positive ions with a focus on 0.9–3 nm sizes. Furthermore, an analysis into meteorological conditions and the coincidence with night-time activity and daytime NPF days is carried out to identify possible links to conventional photochemically active NPF processes.

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From 11 years of analysed data, a total of 1324 negative and 1174 positive nocturnal ion events (hereafter referred as NIEs) were identified within the geometrical size range of 0.9 to 3 nm (see Fig. 1 for an example of a NIE). This accounts to a third of nights analysed, for both polarities, in accordance with Junninen et al. (2008). Furthermore, a seasonal peak in spring–summer months of April to June is also observed. Median starting times for NIEs are between 19:00 and 20:00, and peak in concentration at ~22:00 hours, for both polarities.

When looking at the frequency of NIE's concurring with a daytime NPF on the same day (pre-NIE) or a day after (post-NIE), both polarities NIEs appear on >70% of NPF event days.

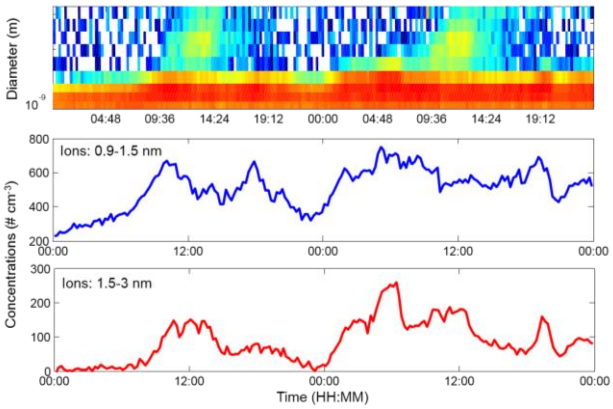

Figure 1. Nocturnal ion event (NIE) between two NPF event days (23–24.March.2003). Notice increase in anion concentration starting at midnight for both 0.9–1.5 nm (blue) and 1.5–3 nm (red) size ranges.

Preliminary results sifting through all NIEs that would still be considered as such at the 2–3 nm range (to remove the ubiquitous ion cluster pool concentrations) have shown an approximate 10% of NIEs to be in the same order of magnitude in concentration number to those during daytime NPF 2–3 nm range. Days with precipitation have been removed to avoid ionisation from rain. Furthermore, a recurrent characteristic of night-time activities is a 'bump' at around 7–8pm, with no growth. It must be noted that at the latitude of the study area, a starting time in the evening at 7–8 pm could still correspond to pre-sunset hours; however, peak concentrations were found along sunset hours, and a possible link to boundary layer dynamics (and entrapment of potential vapours) are being analysed, as well as overall meteorology and radiation conditions during these nights, specifically on the 2–3 nm increases in concentration and their lack of growth.

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